



## CLAIMS LISTING

1 3 1. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic  
2 4 communications network, comprising:

5 organizing a wireless electromagnetic communications network, comprising

6 a set of nodes, said set of nodes further comprising,

7 at least a first subset wherein each node is MIMO-capable,

8 comprising:

9 an antennae array of  $M$  antennae, where  $M \geq$  one,

10 a transceiver for each antenna in said spatially diverse

11 antennae array,

12 means for digital signal processing to convert analog radio  
13 signals into digital signals and digital signals into analog  
14 radio signals,

15 means for coding and decoding data, symbols, and control  
16 information into and from digital signals,

17 diversity capability means for transmission and reception of  
18 said analog radio signals,

19 and,

20 means for input and output from and to a non-radio  
21 interface for digital signals;

22 linking said set of nodes ~~being deployed~~ according to design rules that  
23 favor prefer meeting the following criteria:

24 subdividing said set of nodes further comprising into two or more  
25 proper subsets of nodes, with a first proper subset being the a  
26 transmit uplink / receive downlink subset, and a second proper  
27 subset being the a transmit downlink / receive uplink subset;

28 allowing each node in said set of nodes to simultaneously belong  
29 belonging to no more up to as many transmitting uplink or  
30 receiving uplink subsets than as it has diversity capability means;

31                   allowing each node in a the transmit uplink / receive downlink  
32                   subset ~~has no more to simultaneously link to up to as many~~ nodes  
33                   with which it will hold time and frequency coincident  
34                   communications in its field of view, ~~than as~~ it has diversity  
35                   capability means;

36                   allowing each node in a the transmit downlink / receive uplink  
37                   subset ~~has no more to simultaneously link to up to as many~~ nodes  
38                   with which it will hold time and frequency coincident  
39                   communications in its field of view, ~~than as~~ it has diversity  
40                   capability means;

41                   allowing each member of a the transmit uplink / receive downlink  
42                   subset ~~cannot hold to engage in simultaneous,~~ time and frequency  
43                   coincident communications with any other member of that transmit  
44                   uplink / receive downlink subset only if both that other member  
45                   also belongs to a different proper subset and the communication is  
46                   between different proper subsets;

47                   and,

48                   allowing each member of a the transmit downlink / receive uplink  
49                   subset ~~cannot hold to engage in simultaneous,~~ time and frequency  
50                   coincident communications with any other member of that transmit  
51                   downlink / receive uplink subset if both that other member also  
52                   belongs to a different proper subset and the communication is  
53                   between different proper subsets;

54                   transmitting, in said wireless electromagnetic communications network,  
55                   independent information from each node belonging to a first proper subset, to one  
56                   or more receiving nodes belonging to a second proper subset that are viewable  
57                   from the transmitting node;

58                   processing independently, in said wireless electromagnetic communications  
59                   network, at each receiving node belonging to said second proper subset,  
60                   information transmitted from one or more nodes belonging to said first proper  
61                   subset;

62 and,

63 dynamically adapting the diversity capability means and said proper subsets to  
64 optimize said network.

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67 2. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic  
68 communications network, comprising:

69 organizing a wireless electromagnetic communications network, comprising

70 a set of nodes, said set of nodes further comprising,

71 at least a first subset wherein each node is MIMO-capable,  
72 comprising:

73 a spatially diverse antennae array of  $M$  antennae, where  $M$   
74  $\geq$  two,

75 a transceiver for each antenna in said spatially diverse  
76 antennae array,

77 means for digital signal processing to convert analog radio  
78 signals into digital signals and digital signals into analog  
79 radio signals,

80 means for coding and decoding data, symbols, and control  
81 information into and from digital signals,

82 diversity capability means for transmission and reception of  
83 said analog radio signals,

84 and,

85 means for input and output from and to a non-radio  
86 interface for digital signals;

87 linking said set of nodes ~~being deployed~~ according to design rules that  
88 favor ~~prefer~~ meeting the following criteria:

89 subdividing said set of nodes ~~further comprising~~ into two or more  
90 proper subsets of nodes, with a first proper subset being ~~a~~ the  
91 transmit uplink / receive downlink subset, and a second proper  
92 subset being ~~a~~ the transmit downlink / receive uplink subset;

93 allowing each node in said set of nodes to simultaneously belong  
94 belonging to no more up to as many transmitting uplink or  
95 receiving uplink subsets than as it has diversity capability means;  
96 allowing each node in a the transmit uplink / receive downlink  
97 subset has no more to simultaneously link to up to as many nodes  
98 with which it will hold time and frequency coincident  
99 communications in its field of view, than as it has diversity  
100 capability means;  
101 allowing each node in a the transmit downlink / receive uplink  
102 subset has no more to simultaneously link to up to as many nodes  
103 with which it will hold time and frequency coincident  
104 communications in its field of view, than as it has diversity  
105 capability means;  
106 allowing each member of a the transmit uplink / receive downlink  
107 subset cannot hold to engage in simultaneous time and frequency  
108 coincident communications with any other member of that transmit  
109 uplink / receive downlink subset only if both that other member  
110 also belongs to a different proper subset and the communication is  
111 between different proper subsets;  
112 and,  
113 allowing each member of a the transmit downlink / receive uplink  
114 subset cannot hold to engage in simultaneous time and frequency  
115 coincident communications with any other member of that transmit  
116 downlink / receive uplink subset only if both that other member  
117 also belongs to a different proper subset and the communication is  
118 between different proper subsets;  
119 transmitting, in said wireless electromagnetic communications network,  
120 independent information from each node belonging to a first proper subset, to one  
121 or more receiving nodes belonging to a second proper subset that are viewable  
122 from the transmitting node;

123 processing independently, in said wireless electromagnetic communications  
124 network, at each receiving node belonging to said second proper subset,  
125 information transmitted from one or more nodes belonging to said first proper  
126 subset;  
127 and,  
128 dynamically adapting the diversity capability means and said proper subsets to  
129 optimize said network.

130  
131  
132 3. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically  
133 adapting the diversity capability means and said proper subsets to optimize said network  
134 further comprises:

135 using substantive null steering to minimize SINR between nodes transmitting and  
136 receiving information.

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138  
139 4. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically  
140 adapting the diversity capability means and said proper subsets to optimize said network  
141 further comprises:

142 using max-SINR null- and beam-steering to minimize intra-network interference.

143  
144  
145 5. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically  
146 adapting the diversity capability means and said proper subsets to optimize said network  
147 further comprises:

148 using MMSE null- and beam-steering to minimize intra-network interference.

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151 6. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically  
152 adapting the diversity capability means and said proper subsets to optimize said network  
153 further comprises:

154

155       designing the network such that reciprocal symmetry exists for each pairing of

156       uplink receive and downlink receive proper subsets.

157

158   7. (PREVIOUSLY PRESENTED)   A method as in claim 1, wherein dynamically

159       adapting the diversity capability means and said proper subsets to optimize said network

160       further comprises:

161

162       designing the network such that substantial reciprocal symmetry exists for each

163       pairing of uplink receive and downlink receive proper subsets.

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165   8. (original)   A method as in claim 1, wherein the network uses TDD communication

166       protocols.

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168   9. (original)   A method as in claim 1, wherein the network uses FDD communication

169       protocols.

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171   10. (original)   A method as in claim 3, wherein the network uses simplex communication

172       protocols.

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174   11. (original)   A method as in claim 1, wherein the network uses random access packets,

175       and receive and transmit operations are all carried out on the same frequency channels for

176       each link.

177

178   12. (PREVIOUSLY PRESENTED)   A method as in claim 1, wherein dynamically

179       adapting the diversity capability means and said proper subsets to optimize said network

180       further comprises

181

182       if the received interference is spatially white in both link directions, setting

183         $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$  and  $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$  at both ends of the link,

184        where

185         $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$  are the linear transmit and receive weights used in the  
186        downlink;

187

188        but if the received interference is not spatially white in both link directions,

189        constraining  $\{\mathbf{g}_1(q)\}$  and  $\{\mathbf{g}_2(q)\}$  to preferentially satisfy:

190

$$191 \quad \sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

192

$$193 \quad \sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2$$

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196        13. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein:

197        a proper subset may incorporate one or more nodes that are in a receive-only  
198        mode for every diversity capability means.

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201        14. (original) A method as in claim 1, wherein:

202        the network may dynamically reassign a node from one proper subset to another.

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205        15. (original) A method as in claim 1, wherein:

206        the network may dynamically reassign a proper subset of nodes from one proper  
207        subset to another.

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 209  
 210 16. (PREVIOUSLY PRESENTED) A method as in claim 7, wherein the step of  
 211 designing the network such that substantial reciprocal symmetry exists for the uplink and  
 212 downlink channels further comprises:  
 213  
 214 if the received interference is spatially white in both link directions, setting  
 215  
 216  $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$  and  $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$  at both ends of the link, where  
 217  $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$  are the linear transmit and receive weights used in the  
 218 downlink;  
 219  
 220 but if the received interference is not spatially white in both link directions,  
 221 constraining  $\{\mathbf{g}_1(q)\}$  and  $\{\mathbf{g}_2(q)\}$  to preferentially satisfy:  
 222  
 223 
$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$
  
 224 
$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2$$
  
 225  
 226  
 227 17. (CANCELLED)  
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231 18. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically  
232 adapting the diversity capability means and said proper subsets to optimize said network  
233 further comprises  
234 using at each node the receive combiner weights as transmit distribution weights  
235 during subsequent transmission operations, so that the network is preferentially  
236 designed and constrained such that each link is substantially reciprocal, such that  
237 the ad hoc network capacity measure can be made equal in both link directions by  
238 setting at both ends of the link:

239

240  $\mathbf{g}_2(k,q) \propto \mathbf{w}_2^*(k,q)$  and  $\mathbf{g}_1(k,q) \propto \mathbf{w}_1^*(k,q)$ ,

241

242 where  $\{\mathbf{g}_2(k,q), \mathbf{w}_1(k,q)\}$  are the linear transmit and receive  
243 weights to transmit data  $d_2(k,q)$  from node  $n_2(q)$  to node  $n_1(q)$   
244 over channel  $k$  in the downlink, and where  $\{\mathbf{g}_1(k,q), \mathbf{w}_2(k,q)\}$  are  
245 the linear transmit and receive weights used to transmit data  $d_1(k,q)$   
246 from node  $n_1(q)$  back to node  $n_2(q)$  over equivalent channel  $k$  in the  
247 uplink.

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251 19. (CURRENTLY AMENDED) A method as in claim 1, wherein the step of ~~each~~  
252 ~~node in a transmit downlink / receive uplink subset having no more nodes with which it~~  
253 ~~will hold time and frequency coincident communications in its field of view, than it has~~  
254 ~~diversity capability means linking said set of nodes according to design rules~~ further  
255 comprises:

256 designing the topological, physical layout of nodes to support the favored criteria  
257 ~~enforce this constraint~~ within the node's diversity capability ~~means~~ means'  
258 limitations.

259

260

261 20. (CURRENTLY AMENDED) A method as in claim 1, wherein the step of ~~each~~  
262 ~~node in a transmit uplink / receive downlink subset having no more nodes with which it~~  
263 ~~will hold time and frequency coincident communications in its field of view, than it has~~  
264 ~~diversity capability means linking said set of nodes according to design rules~~ further  
265 comprises:  
266       designing the topological, physical layout of nodes to support the favored criteria  
267 ~~enforce this constraint~~ within the node's diversity capability ~~means~~ means'  
268       limitations.

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271 21. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
272 dynamically adapting the diversity capability means and said proper subsets to optimize  
273 said network further comprises:  
274       allowing a proper subset to send redundant data transmissions over multiple  
275 frequency channels to another proper subset.

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278 22. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
279 dynamically adapting the diversity capability means and said proper subsets to optimize  
280 said network further comprises:  
281       allowing a proper subset to send redundant data transmissions over multiple  
282 simultaneous or differential time slots to another proper subset.

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285 23. (CURRENTLY AMENDED) A method as in claim 1, wherein ~~said transmitting~~  
286 ~~proper subset and receiving proper subset~~ the step of linking and substep of subdividing  
287 said set of nodes into two or more proper subsets of nodes, does so using as the diversity  
288 capability means for transmission and reception of said analog radio signals spatial  
289 diversity of antennae. further comprise:

290            ~~spatial diversity of antennae.~~

291

292

293    24. (CURRENTLY AMENDED)    A method as in claim 1, wherein ~~said transmitting~~  
294 ~~proper subset and receiving proper subset~~ ~~the step of linking and substep of subdividing~~  
295 ~~said set of nodes into two or more proper subsets of nodes, does so using as the~~ diversity  
296 capability means for transmission and reception of said analog radio signals ~~polarization~~  
297 ~~diversity of antennae further comprise:~~

298            ~~polarization diversity of antennae.~~

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301    25. (CURRENTLY AMENDED)    A method as in claim 1, wherein ~~said transmitting~~  
302 ~~proper subset and receiving proper subset~~ ~~the step of linking and substep of subdividing~~  
303 ~~said set of nodes into two or more proper subsets of nodes, does so using as the~~ diversity  
304 capability means for transmission and reception of said analog radio signals any  
305 combination of temporal, spatial, and polarization diversity of antennae further comprise:

306            ~~any combination of temporal, spatial, and polarization diversity of antennae.~~

307

308

309    26. (PREVIOUSLY PRESENTED)    A method as in claim 1, wherein the step of  
310 dynamically adapting the diversity capability means and said proper subsets to optimize  
311 said network further comprises:

312            incorporating network control and feedback aspects as part of the signal encoding  
313 process.

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315

316    27. (PREVIOUSLY PRESENTED)    A method as in claim 1, wherein the step of  
317 dynamically adapting the diversity capability means and said proper subsets to optimize  
318 said network further comprises:

319            incorporating network control and feedback aspects as part of the signal encoding  
320 process and including said as network information in one direction of the

321 signalling and optimization process, using the perceived environmental  
322 condition's effect upon the signals in the other direction of the signalling and  
323 optimization process.

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326 28. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
327 dynamically adapting the diversity capability means and said proper subsets to optimize  
328 said network further comprises:

329 adjusting the diversity capability means use between any proper sets of nodes by  
330 rerouting any active link based on perceived unacceptable SINR experienced on  
331 that active link and the existence of an alternative available link using said  
332 adjusted diversity capability means.

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335 29. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
336 dynamically adapting the diversity capability means and said proper subsets to optimize  
337 said network further comprises:

338 switching a particular node from one proper subset to another due to changes in  
339 the external environment affecting links between that node and other nodes in the  
340 network.

341

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343 30. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
344 dynamically adapting the diversity capability means and said proper subsets to optimize  
345 said network further comprises:

346 dynamically reshuffling proper subsets to more closely attain network objectives  
347 by taking advantage of diversity capability means availability.

348

349

350 31. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
351 dynamically adapting the diversity capability means and said proper subsets to optimize  
352 said network further comprises:

353       dynamically reshuffling proper subsets to more closely attain network objectives  
354       by accounting for node changes.

355

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357 32. (PREVIOUSLY PRESENTED) A method as in claim 31, wherein said node  
358 changes include any of:

359       adding diversity capability means to a node, adding a new node within the field of  
360       view of another node, removing a node from the network (temporarily or  
361       permanently), or losing diversity capability at a node.

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364 33. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
365 dynamically adapting the diversity capability means and said proper subsets to optimize  
366 said network further comprises:

367       suppressing unintended recipients or transmitters by the imposition of signal  
368       masking.

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371 34. (original) A method as in claim 33, wherein the step of suppressing unintended  
372 recipients or transmitters by the imposition of signal masking further comprises:

373       imposition of an origination mask.

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376 34. (original) A method as in claim 33, wherein the step of suppressing unintended  
377 recipients or transmitters by the imposition of signal masking further comprises:

378       imposition of a recipient mask.

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381 35. (original) A method as in claim 33, wherein the step of suppressing unintended  
382 recipients or transmitters by the imposition of signal masking further comprises:  
383       imposition of any combination of origination and recipient masks.

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386 36. (PREVIOUSLY PRESENTED) A method as in claim 33, wherein the step of  
387 dynamically adapting the diversity capability means and said proper subsets to optimize  
388 said network further comprises:

389       using signal masking to secure transmissions against unintentional, interim  
390       interception and decryption by the imposition of a signal mask at origination, the  
391       transmission through any number of intermediate nodes lacking said signal mask,  
392       and the reception at the desired recipient which possesses the correct means for  
393       removal of the signal mask.

394

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396 37. (original) A method as in claim 36, wherein the signal masking is shared by a proper  
397 subset.

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400 38. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
401 dynamically adapting the diversity capability means and said proper subsets to optimize  
402 said network further comprises:

403       heterogenous combination of a hierarchy of proper subsets, one within the other,  
404       each paired with a separable subset wherein the first is a transmit uplink and the  
405       second is a transmit downlink subset, such that the first subset of each pair of  
406       subsets is capable of communication with the members of the second subset of  
407       each pair, yet neither subset may communicate between its own members.

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410 39. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
411 dynamically adapting the diversity capability means and said proper subsets to optimize  
412 said network further comprises:  
413       using as many of the available diversity capability means as are needed for traffic  
414       between any two nodes from 1 to NumChannels, where NumChannels equals the  
415       maximal diversity capability means between said two nodes.  
416  
417  
418 40. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
419 dynamically adapting the diversity capability means and said proper subsets to optimize  
420 said network further comprises:  
421       using a water-filling algorithm to route traffic between an origination and  
422       destination node through any intermediate subset of nodes that has available  
423       diversity capability means capacity.  
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425  
426 41. (CURRENTLY AMENDED) A method for optimizing a wireless  
427 electromagnetic communications network, comprising:  
428       organizing a wireless electromagnetic communications network, comprising  
429       a set of nodes, said set further comprising,  
430       at least a first subset of MIMO-capable nodes, each MIMO-  
431       capable node comprising:  
432        a spatially diverse antennae array of  $M$  antennae, where  $M$   
433         $\geq$  two, said antennae array being polarization diverse, and  
434        circularly symmetric, and providing 1-to- $M$  RF feeds;  
435        a transceiver for each antenna in said array, said transceiver  
436        further comprising  
437        a Butler Mode Forming element, providing spatial  
438        signature separation with a FFT-LS algorithm,  
439        reciprocally forming a transmission with shared  
440        receiver feeds, such that the number of modes out

441 equals the numbers of antennae, establishing such  
442 as an ordered set with decreasing energy, further  
443 comprising:

444 a dual-polarization element for splitting the  
445 modes into positive and negative polarities  
446 with opposite and orthogonal polarizations,  
447 that can work with circular polarizations,  
448 and

449 a dual-polarized link CODEC;

450 a transmission/reception switch comprising,  
451 a vector OFDM receiver element;  
452 a vector OFDM transmitter element;  
453 a LNA bank for a receive signal, said LNA  
454 Bank also instantiating low noise  
455 characteristics for a transmit signal;  
456 a PA bank for the transmit signal that  
457 receives the low noise characteristics for  
458 said transmit signal from said LNA bank;  
459 an AGC for said LNA bank and PA bank;  
460 a controller element for said  
461 transmission/reception switch enabling  
462 baseband link distribution of the energy over  
463 the multiple RF feeds on each channel to  
464 steer up to  $K_{\text{feed}}$  beams and nulls  
465 independently on each FDMA channel;  
466 a Frequency Translator;  
467 a timing synchronization element controlling  
468 said controller element;  
469 further comprising a system clock,  
470 a universal Time signal element;  
471 GPS;

472 a multimode power management element  
473 and algorithm;  
474 and,  
475 a LOs element;  
476 said vector OFDMreceiver element comprising  
477 an ADC bank for downconversion of  
478 received RF signals into digital signals;  
479 a MT DEMOD element for multitone  
480 demodulation, separating the received signal  
481 into distinct tones and splitting them into 1  
482 through  $K_{\text{feed}}$  FDMA channels, said  
483 separated tones in aggregate forming the  
484 entire baseband for the transmission, said  
485 MT DEMOD element further comprising  
486 a Comb element with a multiple of 2  
487 filter capable of operating on a 128-  
488 bit sample; and,  
489 an FFT element with a 1,024 real-IF  
490 function;  
491 a Mapping element for mapping the  
492 demodulated multitone signals into a 426  
493 active receive bins, wherein  
494 each bin covers a bandwidth of 5.75  
495 MHz;  
496 each bin has an inner passband of  
497 4.26 MHz for a content envelope;  
498 each bin has an external buffer, up  
499 and down, of 745 kHz;  
500 each bin has 13 channels, CH0  
501 through CH12, each channel having  
502 320 kHz and 32 tones, T0 through



532 to adapt transmission gains  $\mathbf{G}(k)$  for each  
533 channel  $k$ ;  
534 an equalization algorithm, taking the signal  
535 from said multilink diversity combining  
536 element and controlling a delay removal  
537 element;  
538 said delay removal element separating signal  
539 content from imposed pseudodelay and  
540 experienced environmental signal delay, and  
541 passing the content-bearing signal to a  
542 symbol-decoding element;  
543 said symbol-decoding element for  
544 interpretation of the symbols embedded in  
545 the signal, further comprising:  
546 an element for delay gating;  
547 a QAM element; and  
548 a PSK element;  
549 said vector OFDM transmitter element comprising:  
550 a DAC bank for conversion of digital signals  
551 into RF signals for transmission;  
552 a MT MOD element for multitone  
553 modulation, combining and joining the  
554 signal to be transmitted from 1 through  $K_{\text{feed}}$   
555 FDMA channels, said separated tones in  
556 aggregate forming the entire baseband for  
557 the transmission, said MT MOD element  
558 further comprising  
559 a Comb element with a multiple of 2  
560 filter capable of operating on a 128-  
561 bit sample; and,

562 an IFFT element with a 1,024 real-IF  
563 function;  
564 a Mapping element for mapping the  
565 modulated multitone signals from 426  
566 active transmit bins, wherein  
567 each bin covers a bandwidth of 5.75  
568 MHz;  
569 each bin has an inner passband of  
570 4.26 MHz for a content envelope;  
571 each bin has an external buffer, up  
572 and down, of 745 kHz;  
573 each bin has 13 channels, CH0  
574 through CH12, each channel having  
575 320 kHz and 32 tones, T0 through  
576 T31, each tone being 10 kHz, with  
577 the inner 30 tones being used  
578 information bearing and T0 and T31  
579 being reserved;  
580 each signal being-100  $\mu$ s, with 12.5  
581  $\mu$ s at each end thereof at the front  
582 and rear end thereof forming  
583 respectively a cyclic prefix and  
584 cyclic suffix buffer to punctuate  
585 successive signals;  
586 a MUX element for timing modification  
587 capable of element-wise multiplication  
588 across the signal, which halves the number  
589 of bins and tones but repeats the signal for  
590 high-quality needs;

591 a symbol-coding element for embedding the  
592 symbols to be interpreted by the receiver in  
593 the signal, further comprising:  
594       an element for delay gating;  
595       a QAM element; and  
596       a PSK element;  
597 a link CODEC, which aggregates each  
598 FDMA channel from 1 through  $M$  links,  
599 further comprising  
600       a SOVA bit recovery element;  
601       an error coding element;  
602       an error detection element;  
603       an ITI remove element;  
604       a tone equalization element;  
605       and,  
606       a package fragment retransmission  
607       element;  
608 a multilink diversity distribution element,  
609 using a multilink Tx weight adaptation  
610 algorithm for Tx signal weights to adapt  
611 transmission gains  $\mathbf{G}(k)$  for each channel  
612  $k$ , such that  $\mathbf{g}(q;k) \propto \mathbf{w}^*(q;k)$ ;  
613 a TCM codec;  
614 a pilot symbol CODEC element that integrates with said  
615 FFT-LS algorithm a link separation, a pilot and data signal  
616 elements sorting, a link detection, multilink combination,  
617 and equalizer weight calculation operations;  
618 means for diversity transmission and reception,  
619 and,

620 means for input and output from and to a non-radio  
621 interface;

622

623 linking said set of nodes ~~being deployed~~ according to design rules that  
624 ~~favor~~ prefer meeting the following criteria:

625 subdividing said set of nodes ~~further comprising into~~ two or more  
626 proper subsets of nodes, with a first proper subset being ~~the~~ a  
627 transmit uplink / receive downlink subset, and a second proper  
628 subset being ~~the~~ a transmit downlink / receive uplink subset;

629

630 allowing each node in said set of nodes to simultaneously belong  
631 ~~belonging~~ to ~~no more~~ only as many transmitting uplink or  
632 receiving uplink subsets ~~than as~~ it has diversity capability means;

633

634 allowing each node in a the transmit uplink / receive downlink  
635 subset ~~has no more~~ to simultaneously link to only as many nodes  
636 with which it will hold time and frequency coincident  
637 communications in its field of view, ~~than as~~ it has diversity  
638 capability means;

639

640 allowing each node in a the transmit downlink / receive uplink  
641 subset ~~has no more~~ to simultaneously link to only as many nodes  
642 with which it will hold time and frequency coincident  
643 communications in its field of view, ~~than as~~ it has diversity  
644 capability means;

645

646 allowing each member of a the transmit uplink / receive downlink  
647 subset ~~cannot hold~~ to engage in simultaneous, time and frequency  
648 coincident communications with any other member of that transmit  
649 uplink / receive downlink subset only if both that other member  
650 also belongs to a different proper subset and the communication is  
between different proper subsets;

651 and,

652 allowing each member of a the transmit downlink / receive uplink  
653 subset cannot hold to engage in simultaneous, time and frequency  
654 coincident communications with any other member of that transmit  
655 downlink / receive uplink subset only if both that other member  
656 also belongs to a different proper subset and the communication is  
657 between different proper subsets;

658

659 transmitting, in said wireless electromagnetic communications network,  
660 independent information from each node belonging to a first proper subset, to one  
661 or more receiving nodes belonging to a second proper subset that are viewable  
662 from the transmitting node;

663

664 processing independently, in said wireless electromagnetic communications network,  
665 at each receiving node belonging to said second proper subset,  
666 information transmitted from one or more nodes belonging to said first proper  
667 subset;

668

669 and,

670

671 designing the network such that substantially reciprocal symmetry exists for the  
672 uplink and downlink channels by,

673 if the received interference is spatially white in both link directions, setting

674  $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$  and  $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$  at both ends of the link,

675 where  $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$  are the linear transmit and receive weights  
676 used in the downlink;

677

678 but if the received interference is not spatially white in both link  
679 directions, constraining  $\{\mathbf{g}_1(q)\}$  and  $\{\mathbf{g}_2(q)\}$  to satisfy:

680

$$681 \quad \sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

682

$$683 \quad \sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2;$$

684

685       using any standard communications protocol, including TDD, FDD, simplex,

686

687       and,

688

689       optimizing the network by dynamically adapting the diversity capability means  
690       between nodes of said transmitting and receiving subsets.

691

692

693       42. (CANCELLED)

694

695

696       43. (CANCELLED)

697

698

699       44. (PREVIOUSLY PRESENTED)                   A method as in claim 1, wherein the step of  
700       dynamically adapting the diversity capability means and said proper subsets to optimize  
701       said network further comprises:

702               optimizing at each node acting as a receiver the receive weights using a MMSE  
703               technique to adjust the multitone transmissions between it and other nodes.

704

705

705 45. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
706 dynamically adapting the diversity capability means and said proper subsets to optimize  
707 said network further comprises:

708       optimizing at each node acting as a receiver the receive weights using the MAX  
709       maximum SINR to adjust the multitone transmissions between it and other nodes.

710

711

712 46. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
713 dynamically adapting the diversity capability means and said proper subsets to optimize  
714 said network further comprises:

715       optimizing at each node acting as a receiver the receive weights, then optimizing  
716       the transmit weights at that node by making them proportional to the receive  
717       weights, and then optimizing the transmit gains for that node by a max-min  
718       criterion for the link capacities for that node at that particular time.

719

720

721 47. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
722 dynamically adapting the diversity capability means and said proper subsets to optimize  
723 said network further comprises:

724       including, as part of said network, one or more network controller elements that  
725       assist in tuning local node's maximum capacity criteria and link channel diversity  
726       usage to network constraints.

727

728

729 48. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
730 dynamically adapting the diversity capability means and said proper subsets to optimize  
731 said network further comprises:

732 characterizing the channel response vector  $\mathbf{a}_1(f,t;n_2, n_1)$  by the observed  
733 (possibly time-varying) azimuth and elevation  $\{\theta_1(t;n_2, n_1),$   
734  $\varphi_1(f,t;n_2, n_1)\}$  of node  $n_2$  observed at  $n_1$ .

735  
736

737 49. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
738 dynamically adapting the diversity capability means and said proper subsets to optimize  
739 said network further comprises:

740 characterizing the channel response vector  $\mathbf{a}_1(f,t;n_2, n_1)$  as a superposition of  
741 direct-path and near-field reflection path channel responses, e.g., due to scatterers  
742 in the vicinity of  $n_1$ , such that each element of  $\mathbf{a}_1(f,t;n_2, n_1)$  can be modeled  
743 as a random process, possibly varying over time and frequency.

744  
745

746 50. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
747 dynamically adapting the diversity capability means and said proper subsets to optimize  
748 said network further comprises:

749 presuming that  $\mathbf{a}_1(f,t;n_2, n_1)$  and  $\mathbf{a}_1(f,t;n_1, n_2)$  can be substantively  
750 time invariant over significant time durations, e.g., large numbers of OFDM  
751 symbols or TDMA time frames, and inducing the most significant frequency and  
752 time variation by the observed timing and carrier offset on each link.

753  
754

755 51. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
756 dynamically adapting the diversity capability means and said proper subsets to optimize  
757 said network further comprises:

758 in such networks, e.g., TDD networks, wherein the transmit and receive  
759 frequencies are identical ( $f_{21}(k) = f_{12}(k) = f(k)$ ) and the transmit and  
760 receive time slots are separated by short time intervals ( $t_{21}(l) = t_{12}(l) + \Delta_{21}$   
761  $\approx t(l)$ ), and  $\mathbf{H}_{21}(k, l)$  and  $\mathbf{H}_{12}(k, l)$  become substantively reciprocal,  
762 such that the subarrays comprising  $\mathbf{H}_{21}(k, l)$  and  $\mathbf{H}_{12}(k, l)$  satisfy  
763  $\mathbf{H}_{21}(k, l; n_2, n_1) \approx \delta_{21}(k, l; n_1, n_2) \mathbf{H}_{12}^T(k, l; n_1, n_2)$ , where  
764  $\delta_{21}(k, l; n_1, n_2)$  is a unit-magnitude, generally nonreciprocal scalar,  
765 equalizing the observed timing offsets, carrier offsets, and phase offsets, such that  
766  $\lambda_{21}(n_2, n_1) \approx \lambda_{12}(n_1, n_2)$ ,  $\tau_{21}(n_2, n_1) \approx \tau_{12}(n_1, n_2)$ , and  
767  $\nu_{21}(n_1, n_2) \approx \nu_{12}(n_1, n_2)$ , by synchronizing each node to an external,  
768 universal time and frequency standard, obtaining  $\delta_{21}(k, l; n_2, n_1) \approx 1$ ,  
769 and establishing network channel response as truly reciprocal  $\mathbf{H}_{21}(k, l) \approx$   
770  $\mathbf{H}_{12}^T(k, l)$ .

771  
772  
773 52.(original) A method as in claim 51, wherein the synchronization of each node is to  
774 Global Position System Universal Time Coordinates (GPS UTC).

775  
776  
777 53. (original) A method as in claim 51, wherein the synchronization of each node is to a  
778 network timing signal.

779  
780

782 54. (original) A method as in claim 51, wherein the synchronization of each node is to a  
783 combination of Global Position System Universal Time Coordinates (GPS UTC) and a  
784 network timing signal.

785

786

787 55. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
788 dynamically adapting the diversity capability means and said proper subsets to optimize  
789 said network further comprises:

790 for such parts of the network where the internode channel responses possess  
791 substantive multipath, such that  $\mathbf{H}_{21}(k, l; n_2, n_1)$  and  $\mathbf{H}_{12}(k, l; n_1, n_2)$   
792 have rank greater than unity, making the channel response substantively  
793 reciprocal by:

794

795 (1) forming uplink and downlink transmit signals using the matrix formula

796  $\mathbf{s}_1(k, l; n_1) = \mathbf{G}_1(k, l; n_1) \mathbf{d}_1(k, l; n_1)$

797  $\mathbf{s}_2(k, l; n_1) = \mathbf{G}_2(k, l; n_2) \mathbf{d}_2(k, l; n_2);$

798 (2) reconstructing the data intended for each receive node using the  
799 matrix formula

800  $\mathbf{y}_1(k, l; n_1) = \mathbf{W}_1^H(k, l; n_1) \mathbf{x}_1(k, l; n_1)$

801  $\mathbf{y}_2(k, l; n_2) = \mathbf{W}_2^H(k, l; n_2) \mathbf{x}_2(k, l; n_2);$

802 (3) developing combiner weights that  $\{\mathbf{w}_1(k, l; n_2, n_1)\}$  and  
803  $\{\mathbf{w}_2(k, l; n_1, n_2)\}$  that substantively null data intended for  
804 recipients during the symbol recovery operation, such that for  $n_1 \neq n_2$ :

804 (4) developing distribution weights  $\{\mathbf{g}_1(k, l; n_2, n_1)\}$  and  
805  $\{\mathbf{g}_2(k, l; n_1, n_2)\}$  that perform equivalent substantive nulling  
806 operations during transmit signal formation operations;

807 (5) scaling distribution weights to optimize network capacity and/or power  
808 criteria, as appropriate for the specific node topology and application  
809 addressed by the network;

810 (6) removing residual timing and carrier offset remaining after recovery of  
811 the intended network data symbols;

812 and

813 (7) encoding data onto symbol vectors based on the end-to-end SINR  
814 obtainable between each transmit and intended recipient node, and  
815 decoding that data after symbol recovery operations, using channel coding  
816 and decoding methods develop in prior art.

817 56. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically  
818 adapting the diversity capability means and said proper subsets to optimize said network  
819 further comprises:

821 forming substantively nulling combiner weights using an FFT-based least-squares  
822 algorithms that adapt  $\{\mathbf{W}_1(k, l; n_2, n_1)\}$  and  $\{\mathbf{W}_2(k, l; n_1, n_2)\}$  to  
823 values that minimize the mean-square error (MSE) between the combiner output  
824 data and a known segment of transmitted pilot data;

825 applying the pilot data to an entire OFDM symbol at the start of an adaptation  
826 frame comprising a single OFDM symbol containing pilot data followed by a  
827 stream of OFDM symbols containing information data;

828 wherein the pilot data transmitted over the pilot symbol is preferably given by

829 
$$p_1(k; n_2, n_1) = d_1(k, 1; n_2, n_1)$$

830 
$$= p_{01}(k) p_{21}(k; n_2) p_{11}(k; n_1)$$

831 
$$p_2(k; n_1, n_2) = d_2(k, 1; n_1, n_2)$$

832 
$$= p_{02}(k) p_{12}(k; n_1) p_{22}(k; n_2)$$

833 such that the “pseudodelays”  $\delta_1(n_1)$  and  $\delta_2(n_2)$  are unique to each transmit  
834 node (in small networks), or provisioned at the beginning of communication with  
835 any given recipient node (in which case each will be a function of  $n_1$  and  $n_2$ ),  
836 giving each pilot symbol a pseudorandom component;

837 maintaining minimum spacing between any pseudodelays used to communicate  
838 with a given recipient node that is larger than the maximum expected timing  
839 offset observed at that recipient node, said spacing should also being an integer  
840 multiple of  $1/K$ , where  $K$  is the number of tones used in a single FFT-based LS  
841 algorithm;

842 and if  $K$  is not large enough to provide a sufficiency of pseudodelays, using  
843 additional OFDM symbols for transmission of pilot symbols, either lengthening  
844 the effective value of  $K$ , or reducing the maximum number of originating nodes  
845 transmitting pilot symbols over the same OFDM symbol;

846 also providing  $K$  large enough to allow effective combiner weights to be  
847 constructed from the pilot symbols alone;

848 then obtaining the remaining information-bearing symbols, which are the uplink  
849 and downlink data symbols provided by prior encoding, encryption, symbol  
850 randomization, and channel preemphasis stages, in the adaptation frame, by using

$$851 \quad d_1(k, l; n_2, n_1) = p_1(k; n_2, n_1) d_{01}(k, l; n_2, n_1)$$

$$852 \quad d_2(k, l; n_1, n_2) = p_2(k; n_1, n_2) d_{02}(k, l; n_1, n_2);$$

853 removing at the recipient node, first the pseudorandom pilot components from the  
854 received data by multiplying each tone and symbol by the pseudorandom  
855 components of the pilot signals, using

$$856 \quad d_2(k, l; n_1, n_2) = p_2(k; n_1, n_2) d_{02}(k, l; n_1, n_2)$$

$$857 \quad \mathbf{x}_{02}(k, l; n_2) = c_{01}(k; n_2) \mathbf{x}_2(k, l; n_2);$$

858 thereby transforming each authorized and intended pilot symbol for the recipient  
859 node into a complex sinusoid with a slope proportional to the sum of the  
860 pseudodelay used during the pilot generation procedure, and the actual observed  
861 timing offset for that link, and leaving other, unauthorized pilot symbols, and  
862 symbols intended for other nodes in the network, untransformed and so appearing  
863 as random noise at the recipient node.

864

865

866 57. (PREVIOUSLY PRESENTED) A method as in claim 55, wherein the FFT-Least  
867 Squares algorithm further comprises:

868 using a pilot symbol, which is multiplied by a unit-norm FFT window function;  
869 passing that result to a QR decomposition algorithm and computing orthogonalized  
870 data  $\{\mathbf{q}(k)\}$  and an upper-triangular Cholesky statistics matrix  $\mathbf{R}$ ;

871 then multiplying each vector element of  $\{\mathbf{q}(k)\}$  by the same unit-norm FFT  
 872 window function and passing it through a zero-padded inverse Fast Fourier  
 873 Transform (IFFT) with output length  $PK$ , with padding factor  $P$  to form  
 874 uninterpolated, spatially whitened processor weights  $\{\mathbf{u}(m)\}$ , where lag index  
 875  $m$  is proportional to target pseudodelay  $\delta(m) = m/PK$ ;  
 876 then using the spatially whitened processor weights to estimate the mean-square-  
 877 error (MSE) obtaining for a signal received at each target pseudodelay,  
 878  $\varepsilon(m) = 1 - \|\mathbf{u}(m)\|^2$ , yielding a detection statistic (pseudodelay indicator  
 879 function), with an extreme at IFFT lags commensurate with the observed  
 880 pseudodelay and designed to minimize interlag interference between pilot signal  
 881 features in the pseudodelay indicator function;  
 882 using an extremes-finding algorithm to detect each extreme;  
 883 estimating the location of the observed pseudodelays to sub-lag accuracy;  
 884 determining additional ancillary statistics;  
 885 selecting the extremes beyond a designated MSE threshold;  
 886 interpolating spatially whitened weights  $\mathbf{U}$  from weights near the extremes;  
 887 using the whitened combiner weights  $\mathbf{U}$  to calculate both unwhitened combiner  
 888 weights  $\mathbf{W} = \mathbf{R}^{-1}\mathbf{U}$  to be used in subsequent data recovery operations, and to  
 889 estimate the received channel aperture matrix  $\mathbf{A} = \mathbf{R}^H\mathbf{U}$ , to facilitate ancillary  
 890 signal quality measurements and fast network entry in future adaptation frames;  
 891 and, lastly,  
 892 using an estimated and optimized pseudodelay vector  $\boldsymbol{\delta}_*$  to generate  $\mathbf{c}_1(k) =$   
 893  $\exp\{-j2\pi\boldsymbol{\delta}_*k\}$  (conjugate of  $\{p_{11}(k; n_1)\}$  during uplink receive  
 894 operations, and  $\{p_{22}(k; n_2)\}$  during downlink receive operations), which is then  
 895 used to remove the residual observed pseudodelay from the information bearing  
 896 symbols.

897

898

899 58. (original) A method as in claim 55, wherein the pseudodelay estimation is refined  
900 using a Gauss-Newton recursion using the approximation :

901 
$$\exp\{-j2\pi\Delta(k-k_0)/PK\} \approx 1 - j2\pi\Delta(k-k_0)/PK.$$

902

903

904 59. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein wherein  
905 dynamically adapting the diversity[capability means and said proper subsets to optimize  
906 said network further comprises:

907 using the linear combiner weights provided during receive operations are  
908 construct linear distribution weights during subsequent transmit operations, by  
909 setting distribution weight  $\mathbf{g}_1(k, l; n_2, n_1)$  proportional to  
910  $\mathbf{w}_1^*(k, l; n_2, n_1)$  during uplink transmit operations, and  
911  $\mathbf{g}_2(k, l; n_1, n_2)$  proportional to  $\mathbf{w}_2^*(k, l; n_1, n_2)$  during downlink  
912 transmit operations; thereby making the transmit weights substantively nulling  
913 and thereby allowing each node to form frequency and time coincident two-way  
914 links to every node in its field of view, with which it is authorized (through  
915 establishment of link set and transfer of network/recipient node information) to  
916 communicate.

917

918

919 60. (CURRENTLY AMENDED) A method as in claim 1, wherein the substep of  
920 dynamically adapting the diversity capability means and said proper subsets to optimize  
921 said network at each node in the first subset of nodes further comprises:

922 using a LEGO implementation element and algorithm.

923

924

925 61. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically  
926 adapting the diversity capability means and said proper subsets to optimize said network  
927 further comprises:

928       balancing the power use against capacity for each channel, link, and node, and  
929       hence for the network as a whole by:

930           establishing a capacity objective  $\{\beta(m)\}$  for a user 2 node receiving  
931           from a user 1 node as the target to be achieved by the user 2 node;  
932           solving, at the user 2 node the local optimization problem:

933           
$$\min \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1, \text{ such that}$$

934           
$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m),$$

935           where  $\pi_1(q)$  is the transmit power for link number  $q$  for the user  
936           1 node,

937            $\gamma(q)$  is the signal to interference and noise ratio (SINR) seen at  
938           the output of the beamformer,

939            $\mathbf{1}$  is a vector of all 1s,

940           and,

941            $\boldsymbol{\pi}_1$  is a vector whose  $q^{th}$  element is  $\pi_1(q)$ ,

942           the aggregate set  $Q(m)$  contains a set of links that are grouped  
943           together for the purpose of measuring capacity flows through those  
944           links;

945           using at the user 2 node the local optimization solution to moderate the  
946           transmit and receive weights, and signal information, returned to [user 1  
947           node;

948           and,

950 using said feedback to compare against the capacity objective  $\{\beta(m)\}$   
951 and incrementally adjust the transmit power at each of the user 1 node and  
952 the user 2 node until no further improvement is perceptible.

953

954

955 62. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically  
956 adapting the diversity capability means and said proper subsets to optimize said network  
957 further comprises:

958 using the downlink objective function

$$959 \min \sum_q \pi_2(q) = \mathbf{1}^T \boldsymbol{\pi}_2 \text{ such that } \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \\ 960 \beta(m)$$

961 at each node to perform local optimization;  
962 reporting the required feasibility condition,

$$963 \sum_{q \in Q(m)} \pi_1(q) \leq R_1(m);$$

964 and,

965 modifying  $\beta(m)$  as necessary to stay within the constraint.

966

967

968 63. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein:

969 the capacity constraints  $\beta(m)$  are determined in advance for each proper subset  
970 of nodes, based on known QoS requirements for each said proper subset.

971

972

973 64. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein said network  
974 further seeks to minimize total power in the network as suggested by

$$975 \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m).$$

976

976

977 65. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein said network sets  
978 as a target objective for the network  $\{\beta(m)\}$  the QoS for the network.

979

980

981 66. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein said network sets  
982 as a target objective for the network  $\{\beta(m)\}$  a vector of constraints.

983

984

985 67. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the local  
986 optimization problem is further defined such that:

987

988 the receive and transmit weights are unit normalized with respect to the  
989 background interference autocorrelation matrix;

990

991 the local SINR is expressed as

$$\gamma(q) = \frac{P_{rt}(q, q)\pi_t(q)}{1 + \sum_{j \neq q} P_{rt}(q, j)\pi_t(j)} ;$$

992

993

994 and the weight normalization

$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

995 is used to enable  $D_{12}(\mathbf{W}, \mathbf{G}) = D_{21}(\mathbf{G}^*, \mathbf{W}^*)$ , where  $(\mathbf{W}_2, \mathbf{G}_1)$

996 and  $(\mathbf{W}_1, \mathbf{G}_2)$  represent the receive and transmit weights employed by all  
997 nodes in the network during uplink and downlink operations, respectively, at that  
998 node, thereby allowing the uplink and downlink function to be presumed identical  
999 rather than separately computed.

1001  
 1002  
 1003 68. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein:  
 1004       very weak constraints to the transmit powers are approximated by using a very  
 1005       simple approximation for  $\gamma(q)$ .  
 1006  
 1007  
 1008 69. (PREVIOUSLY PRESENTED) A method as in claim 61, for the cases wherein all  
 1009       the aggregate sets contain a single link and non-negligible environmental noise is present,  
 1010       wherein the transmit powers are computed as Perron vectors from

$$\begin{aligned}
 D_{21} &= \log \left( 1 + \frac{1}{\rho(\mathbf{P}_{21}) - 1} \right) \\
 1011 &= \log \left( 1 + \frac{1}{\rho(\mathbf{P}_{12}^T) - 1} \right); \\
 &= D_{12}
 \end{aligned}$$

1012 and a simple power constraint is imposed upon the transmit powers.  
 1013  
 1014  
 1015 70. (PREVIOUSLY PRESENTED) A method as in claim 69, wherein the optimization  
 1016       is performed in alternating directions and repeated.  
 1017  
 1018  
 1019 71. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein each node  
 1020       presumes the post-beamforming interference energy remains constant for the adjustment  
 1021       interval and so solves

$$\min_{\pi_1(q)} \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1, \text{ subject to the constraint of}$$

1023  $\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$   
1024 using classic water filling arguments based on Lagrange multipliers, and then uses a  
1025 similar equation for the reciprocal element of the link.

1026

1027

1028 72. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein at each node the  
1029 constrained optimization problem stated in

1030  $\max_m \sum_{q \in Q(m)} \log(1 + \gamma(q)),$  such that

1031  $\sum_{q \in Q(m)} \pi_1(q) \leq R_1(m), \gamma(q) \geq 0$

1032 is solved using the approximation

1033 
$$\gamma(q) = \frac{P_{21}(q, q) \pi_1(q)}{i_2(q)}$$

1034 and the network further comprises at least one high-level network controller that controls  
1035 the power constraints  $R_1(m)$ , and drives the network towards a max-min solution.

1036

1037

1038 73. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein each node:

1039 is given an initial  $\gamma_0$ ;

1040 generates the model expressed in

1041 
$$L(\gamma, \mathbf{g}, \beta) = \mathbf{g}^T \gamma, \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

1042 
$$\mathbf{g} = \nabla_{\gamma} f(\gamma_0);$$

1043 updates the new  $\gamma_{\alpha}$  from

1044 
$$\gamma_* = \arg \min_{\gamma} L(\gamma, \mathbf{g}, \beta), \gamma_{\alpha} = \gamma_0 + \alpha(\gamma_* - \gamma_0);$$

1045 determines a target SINR to adapt to; and,

1046 updates the transmit power for each link  $q$  according to

$$1047 \quad \pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

$$1048 \quad \pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2$$

1049

1050 74. (PREVIOUSLY PRESENTED) A method as in claim 61, for each node wherein the  
1051 transmit power relationship of

$$1052 \quad \pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

$$1053 \quad \pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2$$

1054 is not known, that:

1055 uses a suitably long block of  $N$  samples is used to establish the relationship, where  
1056  $N$  is either 4 times the number of antennae or 128, whichever is larger;  
1057 uses the result to update the receive weights at each end of the link;  
1058 optimizes the local model as in

$$1059 \quad \gamma_* = \arg \min_{\gamma} L(\gamma, \mathbf{g}, \beta)$$

$$1060 \quad \gamma_\alpha = \gamma_0 + \alpha(\gamma_* - \gamma_0);$$

1061 and then applies

$$1062 \quad \pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

$$1063 \quad \pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2.$$

1064

1065 75. (PREVIOUSLY PRESENTED) A method as in claim 61 that, for an aggregate  
1066 proper subset  $m$ :

1067 for each node within the set  $m$ , inherits the network objective function model  
1068 given in

1069 
$$L_m(\gamma, \mathbf{g}, \beta) = \sum_{q \in Q(m)} \mathbf{g}_q \gamma(q)$$

1070 
$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

1071 
$$g(q) = i_1(q) i_2(q) / |h(q)|^2 ;$$

1072 eliminates a step of matrix channel estimation, transmitting instead from  
1073 that node as a single real number for each link to the other end of said link  
1074 an estimate of the post beamforming interference power;  
1075 and ,

1076 receives back for each link a single real number being the transmit power.

1077

1078 76. (PREVIOUSLY PRESENTED) A method as in claim 74, that for each pair of  
1079 nodes assigns to the one presently possessing the most processing capability the power  
1080 management computations.

1081

1082

1083 77. (PREVIOUSLY PRESENTED) A method as in claim 75 that estimates the transfer  
1084 gains and the post beamforming interference power using simple least squares estimation  
1085 techniques.

1086

1087

1088 78. (PREVIOUSLY PRESENTED) A method as in claim 75 that, for estimating the  
1089 transfer gains and post beamforming interference power:

1090

1091 instead solves for the transfer gain  $h$  using

1092 
$$y(n) = h g s(n) + \varepsilon(n);$$

1093 uses a block of  $N$  samples of data to estimate  $h$  using

$$1094 \quad h = \frac{\sum_{n=1}^N s^*(n)y(n)}{\sum_{n=1}^N |s(n)|^2 g}$$

1095        obtains an estimation of residual interference power [  $R_\varepsilon$  ] using

$$1096 \quad R_\varepsilon = \left\langle |e(n)|^2 \right\rangle ;$$

$$= \frac{1}{N} \sum_{n=1}^N \left( |y(n)|^2 - |ghs(n)|^2 \right)$$

1097        and,

1098        obtains knowledge of the transmitted data symbols  $s(n)$  from using  
 1099        remodulated symbols at the output of the codec.

1100

1101

1102    79. (PREVIOUSLY PRESENTED) A method as in claim 78 wherein, instead of  
 1103        obtaining knowledge of the transmitted data symbols  $s(n)$  from using remodulated  
 1104        symbols at the output of the codec, the node uses the output of a property restoral  
 1105        algorithm used in a blind beamforming algorithm.

1106

1107

1108    80. (PREVIOUSLY PRESENTED) A method as in claim 78 wherein, instead of  
 1109        obtaining knowledge of the transmitted data symbols  $s(n)$  from using remodulated  
 1110        symbols at the output of the codec, the node uses a training sequence explicitly  
 1111        transmitted to train beamforming weights and asset the power management algorithms.

1112

1113

1114 81. (CURRENTLY AMENDED) A method as in claim 78 wherein, instead of  
1115 obtaining knowledge of the transmitted data symbols  $s(n)$  from using remodulated  
1116 symbols at the output of the codec, the node uses any combination of:  
1117 the output of a property restoral algorithm used in a blind beamforming algorithm;  
1118 a training sequence explicitly transmitted to train beamforming weights and asset  
1119 the power management algorithms;  
1120 or, and,  
1121 other means known to the art.

1122

1123

1124 82. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein each node  
1125 incorporates a link level optimizer and a decision algorithm.

1126

1127 83. (PREVIOUSLY PRESENTED) A method as in claim 82, wherein the decision  
1128 algorithm is a Lagrange multiplier technique.

1129

1130

1131 84. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the solution to  
1132  $\min_{\pi_1(q)} \sum_q \pi_1(q) = \mathbf{1}^T \pi_1$  is implemented by a penalty function technique.

1133

1134

1135 85. (PREVIOUSLY PRESENTED) A method as in claim 84, wherein the penalty  
1136 function technique:  
1137 takes the derivative of  $\gamma(q)$  with respect to  $\pi_1$ ;  
1138 and,  
1139 uses the Kronecker-Delta function and the weighted background noise.

1140

1141

1142 86. (PREVIOUSLY PRESENTED) A method as in claim 84, wherein the penalty  
1143 function technique neglects the noise term.

1144

1145

1146 87. (PREVIOUSLY PRESENTED) A method as in claim 84, wherein the penalty  
1147 function technique normalizes the noise term to one.

1148

1149

1150 88. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the  
1151 approximation uses the receive weights.

1152

1153

1154 89. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein adaptation to the  
1155 target objective is performed in a series of measured and quantized descent and ascent  
1156 steps.

1157

1158 90. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the adaptation to  
1159 the target objective is performed in response to information stating the vector of change.

1160

1161

1162 91. (PREVIOUSLY PRESENTED) A method as in claim 61, which uses the log linear  
1163 mode

$$1164 \quad \beta_q \approx \log \left( \frac{a \pi_1(q) + a_0}{b \pi_1(q) + b_0} \right) = \hat{\beta}_q(\pi_1(q))$$

1165 and the inequality characterization  $\hat{\beta}_q(\pi_1(q)) \geq \beta$  to solve the approximation  
1166 problem with a simple low dimensional linear program.

1167

1168

1169 92. (PREVIOUSLY PRESENTED) A method as in claim 61, develops the local mode  
1170 by matching function values and gradients between the current model and the actual  
1171 function.

1172

1173

1174 93. (PREVIOUSLY PRESENTED) A method as in claim 61, which develops the model  
1175 as a solution to the least squares fit, evaluated over several points.

1176

1177

1178 94. (PREVIOUSLY PRESENTED) A method as in claim 61, which reduces the cross-  
1179 coupling effect by allowing only a subset of links to update at any one particular time,  
1180 wherein the subset members are chosen as those which are more likely to be isolated  
1181 from one another.

1182

1183

1184 95. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein:  
1185       the network further comprises a network controller element;  
1186       said network controller element governs a subset of the network;  
1187       said network controller element initiates, monitors, and changes the target  
1188       objective for that subset;  
1189       said network controller communicates the target objective to each node in that  
1190       subset;  
1191       and,  
1192       receives information from each node concerning the adaptation necessary to meet  
1193       said target objective.

1194

1195

1196 96. (PREVIOUSLY PRESENTED) A method as in claim 95, wherein said network  
1197 further records the scalar and history of the increments and decrements ordered by the  
1198 network controller.

1199

1200

1201 97. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a  
1202 target objective may be a power constraint.

1203

1204

1205 98. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a  
1206 target objective may be a capacity maximization subject to a power constraint.

1207

1208

1209 99. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a  
1210 target objective may be a power minimization subject to the capacity attainment to the  
1211 limit possible over the entire network.

1212

1213

1214 100. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a  
1215 target objective may be a power minimization at each particular node in the network  
1216 subject to the capacity constraint at that particular node.

1217

1218

1219 101. (CURRENTLY AMENDED) A wireless electromagnetic communications  
1220 network, comprising:

1221       a wireless electromagnetic communications network, comprising

1222            a set of nodes, said set further comprising,

1223               at least a first subset wherein each node is MIMO-capable,

1224               comprising:

1225                    a spatially diverse antennae array of M antennae, where M

1226                     $\geq$  one,

1227                    a transceiver for each antenna in said array,

1228                    means for digital signal processing,

1229                    means for coding and decoding data and symbols,

1230                    means for diversity transmission and reception,

1231 and,  
1232 means for input and output from and to a non-radio  
1233 interface;  
1234 said set of nodes further comprising one or more proper subsets of nodes,  
1235 being at least one transmitting and at least one receiving subset, with said  
1236 transmitting and receiving subsets having a topological arrangement  
1237 whereby:  
1238       each node in a transmitting subset has no more nodes with which it  
1239       will simultaneously communicate in its field of view, than it has  
1240       number of antennae;  
1241       each node in a receiving subset has no more nodes with which it  
1242       will simultaneously communicate in its field of view, than it can  
1243       steer independent nulls to;  
1244       and,  
1245       each member of a non-proper subset cannot communicate with any  
1246       other member of its non-proper subset;  
1247 means for transmitting independent information from each node in a first non-  
1248 proper subset to one or more receiving nodes belonging to a second non-proper  
1249 subset that are viewable from the transmitting node;  
1250 means for processing independently information transmitted to a receiving node  
1251 in a second non-proper subset from one or more nodes in a first non-proper subset  
1252 is independently by the receiving node;  
1253       and,  
1254 means for optimizing the network by dynamically adapting the means for diversity  
1255 transmission and reception between nodes of said transmitting and receiving subsets.  
1256  
1257  
1258 102. (PREVIOUSLY PRESENTED)       An apparatus as in claim 101, further  
1259 comprising means for scheduling according to a Demand-Assigned, Multiple-Access  
1260 algorithm.  
1261

1262

1263 103. (CURRENTLY AMENDED) An apparatus as in claim 101, further comprising a  
1264 LEGO adaptation-element for each node in said first subset-a ~~LEGO adaptation element~~.

1265

1266

1267 104. (CURRENTLY AMENDED) An apparatus as in claim 101, further comprising:  
1268       a LEGO adaptation-element for each node in said first subset-a ~~LEGO adaptation~~  
1269       element; and,  
1270       one or more network controllers.

1271

1272

1273 105. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of  
1274 dynamically adapting the diversity capability means and said proper subsets to optimize  
1275 said network further comprises:  
1276       matching each transceiver's degrees of freedom (DOF) to the nodes in the  
1277       possible link directions;  
1278       equalizing those links to provide node-equivalent uplink and downlink capacity.

1279

1280

1281 106. (original) A method as in claim 105, further comprising, after the DOF matching:  
1282       assigning asymmetric transceivers to reflect desired capacity weighting;  
1283       adapting the receive weights to form a solution for multipath resolutions;  
1284       employing data and interference whitening as appropriate to the local conditions;  
1285       and,  
1286       using retrodirective transmission gains during subsequent transmission operations.

1287

1288

1289 107. (original) A method as in claim 105, wherein the receive weights are matched to the  
1290 nodes in the possible link directions.

1291

1292

1293 108. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic  
1294 communications network, comprising:

1295 organizing a wireless electromagnetic communications network, comprising

1296 a set of nodes, said set of nodes further comprising,

1297 at least a first subset wherein each node is MIMO-capable,  
1298 comprising:

1299 an antennae array of  $M$  antennae, where  $M \geq$  one,

1300 a transceiver for each antenna in said spatially diverse  
1301 antennae array,

1302 means for digital signal processing to convert analog radio  
1303 signals into digital signals and digital signals into analog  
1304 radio signals,

1305 means for coding and decoding data, symbols, and control  
1306 information into and from digital signals,

1307 diversity capability means for transmission and reception of  
1308 said analog radio signals;

1309 and,

1310 means for input and output from and to a non-radio  
1311 interface for digital signals;

1312 linking said set of nodes ~~being deployed~~ according to design rules that  
1313 favor ~~prefer~~ meeting the following criteria:

1314

1315 subdividing said set of nodes ~~further comprising~~ into two or more  
1316 proper subsets of nodes, with a first proper subset being ~~the~~ a  
1317 transmit uplink / receive downlink subset, and a second proper  
1318 subset being ~~the~~ a transmit downlink / receive uplink subset;

1319

1320 allowing each node in said set of nodes to simultaneously belong  
1321 ~~belonging~~ to no more up to as many transmitting uplink or  
1322 receiving uplink subsets ~~than as~~ it has diversity capability means;

1323

1324 allowing each node in a the transmit uplink / receive downlink  
1325 subset ~~has no more to simultaneously link to up to as many~~ nodes  
1326 with which it will hold time and frequency coincident  
1327 communications in its field of view, ~~than as~~ it has diversity  
1328 capability means;

1329

1330 allowing each node in a the transmit downlink / receive uplink  
1331 subset has no more to simultaneously link to up to as many nodes  
1332 with which it will hold time and frequency coincident  
1333 communications in its field of view, than as it has diversity  
1334 capability means;

1335

1336 allowing each member of a the transmit uplink / receive downlink  
1337 subset cannot hold to engage in simultaneous time and frequency  
1338 coincident communications with any other member of that transmit  
1339 uplink / receive downlink subset only if both that other member  
1340 also belongs to a different proper subset and the communication is  
1341 between different proper subsets;

1342

1343 allowing each member of a transmit downlink / receive uplink  
1344 subset ~~cannot hold to engage in simultaneous~~ time and frequency  
1345 coincident communications with any other member of that transmit  
1346 downlink / receive uplink subset only if both that other member  
1347 also belongs to a different proper subset and the communication is  
1348 between different proper subsets;

transmitting, in said wireless electromagnetic communications network, independent information from each node belonging to a first proper subset, to one or more receiving nodes belonging to a second proper subset that are viewable from the transmitting node;

1353

1354 processing independently, in said wireless electromagnetic communications  
1355 network, at each receiving node belonging to said second proper subset,  
1356 information transmitted from one or more nodes belonging to said first proper  
1357 subset;

1358

1359 optimizing at the local level for each node for the channel capacity  $D_{21}$   
1360 according to

$$D_{21} = \max \beta \text{ such that}$$

$$\beta \leq \sum_{q \in U(m)} \sum_k \log(1 + \gamma(k, q)),$$

$$\gamma(k, q) \geq 0,$$

1361  $\sum_m R_1(m) \leq R,$  ;

$$\pi_1(k, q) \geq 0,$$

$$\sum_{q \in U(m)} \sum_k \pi_1(k, q) \leq R_1(m)$$

1362 solving first the reverse link power control problem; then treating the forward link  
1363 problem in an identical fashion, substituting the subscripts 2 for 1 in said  
1364 equation;

1365 and,

1366 dynamically adapting the diversity capability means and said proper subsets to  
1367 optimize said network.

1368

1369

1370 109. (PREVIOUSLY PRESENTED) A method as in claim 108, further comprising:

1371

1372 for each aggregate subset  $m$ , attempting to achieve the given capacity objective,  
1373  $\beta$ , as described in

1374 
$$\min_{\pi_r(q)} \sum_{q \in Q(m)} \pi_r(q), \quad \text{such that}$$

1375 
$$\beta = \sum_{q \in Q(m)} \log(1 + \gamma(q))$$

1376 by:

1377 (1) optimizing the receive beamformers, using simple MMSE processing, to  
1378 simultaneously optimize the SINR;

1379 (2) based on the individual measured SINR for each  $q$  index, attempt to  
1380 incrementally increase or lower its capacity as needed to match the current target;  
1381 and,

1382 (3) stepping the power by a quantized small step in the appropriate direction;  
1383 then,

1384 when all aggregate sets have achieved the current target capacity, then the  
1385 network can either increase the target capacity  $\beta$ , or add additional users to  
1386 exploit the now-known excess capacity.

1387

1388

1389 110. (PREVIOUSLY PRESENTED) A method as in claim 107, wherein the network  
1390 optimizes for QoS and not diversity capability means capacity.

1391

1392 111. (PREVIOUSLY PRESENTED) A method as in claim 95, wherein:  
1393 said network controller adds, drops, or changes the target capacity for any node in  
1394 the set the network controller controls.

1395

1396

1397 112. (PREVIOUSLY PRESENTED) A method as in claim 95, wherein:  
1398 said network controller may, either in addition to or in replacement for altering  $\beta$ ,  
1399 add, drop, or change channels between nodes, frequencies, coding, security, or

1400       protocols, polarizations, or traffic density allocations usable by a particular node  
1401       or channel.

1402

1403

1404       113. (PREVIOUSLY PRESENTED) A wireless electromagnetic communications  
1405       network, comprising:

1406            a set of nodes, said set further comprising,  
1407                  at least a first subset wherein each node is MIMO-capable,  
1408                  comprising:  
1409                    a spatially diverse antennae array of  $M$  antennae, where  $M$   
1410                     $\geq$  one,  
1411                    a transceiver for each antenna in said array,  
1412                    means for digital signal processing,  
1413                    means for coding and decoding data and symbols,  
1414                    means for diversity transmission and reception,  
1415                    pilot symbol coding & decoding element  
1416                    timing synchronization element  
1417                  and,  
1418                  means for input and output from and to a non-radio  
1419                  interface;

1420        said set of nodes further comprising two or more proper subsets of nodes,  
1421        there being at least one transmitting and at least one receiving subset, with  
1422        said transmitting and receiving subsets subset having a diversity  
1423        arrangement whereby:  
1424            each node in a transmitting subset has no more nodes with which it  
1425            will simultaneously communicate in its field of view, than it has  
1426            number of antennae;  
1427            each node in a receiving subset has no more nodes with which it  
1428            will simultaneously communicate in its field of view, than it can  
1429            steer independent nulls to;  
1430            and,

1431 each member of a non-proper subset cannot communicate with any  
1432 other member of its non-proper subset over identical diversity  
1433 channels;

1434 a LEGO adaptation element and algorithm;

1435 a network controller element and algorithm;

1436 whereby each node in a first non-proper subset transmits independent information  
1437 to one or more receiving nodes belonging to a second non-proper subset that are  
1438 viewable from the transmitting node;

1439 each receiving node in said second non-proper subset processes independently

1440 information transmitted to it from one or more nodes in a first non-proper subset independently by the receiving node;

1441 each node uses means to minimize SINR between nodes transmitting and  
1442 receiving information;

1443 the network is designed such that substantially reciprocal symmetry exists for the  
1444 uplink and downlink channels by,

1445 if the received interference is spatially white in both link directions, setting

1446  $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$  and  $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$  at both ends of the link,

1447 where  $\mathbf{g}_2(q), \mathbf{w}_1(q)\}$  are the linear transmit and receive weights used  
1448 in the downlink;

1449 but if the received interference is not spatially white in both link

1450 directions, constraining  $\{\mathbf{g}_1(q)\}$  and  $\{\mathbf{g}_2(q)\}$  to satisfy:

$$1451 \sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

$$1452 \sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2;$$

1453

1456 the network uses any standard communications protocol;  
1457 and,  
1458 the network is optimized by dynamically adapting the means for diversity  
1459 transmission and reception between nodes of said transmitting and receiving  
1460 subsets.

1461

1462

1463 114. (PREVIOUSLY PRESENTED) A wireless electromagnetic communications  
1464 network as in claim 113:  
1465 wherein each node may further comprise a Butler Mode Forming element, to  
1466 enable said node to ratchet the number of active antennae for a particular uplink  
1467 or downlink operation up or down.

1468

1469

1470 115. (PREVIOUSLY PRESENTED) A wireless electromagnetic communications  
1471 network as in claim 101:  
1472 incorporating a dynamics-resistant multitone element.

1473

1474

1475 116. (original) The use of a method as described in claim 1 for fixed wireless  
1476 electromagnetic communications.

1477

1478 117. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1479 for fixed wireless electromagnetic communications.

1480

1481 118. (original) The use of a method as described in claim 1 for mobile wireless  
1482 electromagnetic communications.

1483

1484 119. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1485 for mobile wireless electromagnetic communications.

1486

1487 120. (original) The use of a method as described in claim 1 for mapping operations using  
1488 wireless electromagnetic communications.

1489

1490 121. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1491 for mapping operations using wireless electromagnetic communications.

1492

1493 122. (original) The use of a method as described in claim 1 for a military wireless  
1494 electromagnetic communications network.

1495

1496 123. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1497 for a military wireless electromagnetic communications network.

1498

1499 124. (original) The use of a method as described in claim 1 for a military wireless  
1500 electromagnetic communications network for battlefield operations.

1501

1502 125. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1503 for a military wireless electromagnetic communications network for battlefield  
1504 operations.

1505

1506 126. (original) The use of a method as described in claim 1 for a military wireless  
1507 electromagnetic communications network for Back Edge of Battle Area (BEBA)  
1508 operations.

1509

1510 127. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1511 for a military wireless electromagnetic communications network for Back Edge of Battle  
1512 Area (BEBA) operations.

1513

1514 128. (original) The use of a method as described in claim 1 for a wireless electromagnetic  
1515 communications network for intruder detection operations.

1516

1517 129. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1518 for a wireless electromagnetic communications network for intruder detection operations.  
1519

1520 130. (original) The use of a method as described in claim 1 for a wireless electromagnetic  
1521 communications network for logistical intercommunications.  
1522

1523 131. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1524 for a wireless electromagnetic communications network for logistical  
1525 intercommunications.  
1526

1527 132. (original) The use of a method as described in claim 1 in a wireless electromagnetic  
1528 communications network for self-filtering spoofing signals.  
1529

1530 133. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1531 for a wireless electromagnetic communications network for self-filtering spoofing  
1532 signals.  
1533

1534 134. (original) The use of a method as described in claim 1 in a wireless  
1535 electromagnetic communications network for airborne relay over the horizon.  
1536

1537 135. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1538 for a wireless electromagnetic communications network for airborne relay over the  
1539 horizon.  
1540

1541 136. (original) The use of a method as described in claim 1 in a wireless electromagnetic  
1542 communications network for traffic control.  
1543

1544 137. (PREVIOUSLY PRESENTED) The use of a method as in claim 1, further  
1545 comprising the use thereof for air traffic control.  
1546

1547 138. (PREVIOUSLY PRESENTED) The use of a method as in claim 1, further  
1548 comprising the use thereof for ground traffic control.

1549

1550 139. (PREVIOUSLY PRESENTED) The use of a method as in claim 1, further  
1551 comprising the use thereof for a mixture of ground and air traffic control.

1552

1553 140. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101  
1554 for a wireless electromagnetic communications network for traffic control.

1555

1556 141. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101, further  
1557 comprising the use thereof for air traffic control

1558

1559 142. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101, further  
1560 comprising the use thereof for ground traffic control.

1561

1562 143. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101, further  
1563 comprising the use thereof for a mixture of ground and air traffic control.

1564

1565 144. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1566 communications network for emergency services.

1567

1568 145. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1569 wireless electromagnetic communications network for emergency services.

1570

1571 146. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1572 communications network for shared emergency communications without interference.

1573

1574 147. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1575 wireless electromagnetic communications network for shared emergency  
1576 communications without interference.

1577

1578 148. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1579 communications network for positioning operations without interference.  
1580

1581 149. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1582 wireless electromagnetic communications network for positioning operations without  
1583 interference.  
1584

1585 150. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1586 communications network for high reliabilty networks requiring graceful degradation  
1587 despite environmental conditions or changes..  
1588

1589 151. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1590 wireless electromagnetic communications network for high reliabilty networks requiring  
1591 graceful degradation despite environmental conditions or changes..  
1592

1593 152. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1594 communications network for a secure network requiring assurance against unauthorized  
1595 intrusion.  
1596

1597 153. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1598 communications network for a secure network requiring message end-point assurance.  
1599

1600 154. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1601 communications network for a secure network requiring assurance against unauthorized  
1602 intrusion and message end-point assurance.  
1603

1604 155. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1605 wireless electromagnetic communications network for a secure network requiring  
1606 assurance against unauthorized intrusion.  
1607

1608 156. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1609 wireless electromagnetic communications network for a secure network requiring  
1610 message end-point assurance.

1611

1612 157. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 In a  
1613 wireless electromagnetic communications network for a secure network requiring  
1614 assurance against unauthorized intrusion and message end-point assurance.

1615

1616

1617 158. (original) The use of a method as in claim 1 in a cellular mobile radio service.

1618

1619 159. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1620 cellular mobile radio service.

1621

1622 160. (original) The use of a method as in claim 1 in a personal communication service.

1623

1624 161. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1625 personal communication service.

1626

1627 162. (original) The use of a method as in claim 1 in a private mobile radio service.

1628

1629 163. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a private  
1630 mobile radio service.

1631

1632 164. (original) The use of a method as in claim 1 in a wireless LAN.

1633

1634 165. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1635 wireless LAN.

1636

1637 166. (original) The use of a method as in claim 1 in a fixed wireless access service.

1638

1639 167. (currently amended) The use of an apparatus as in claim 50[101]in a fixed wireless  
1640 access service.

1641

1642 168. (original) The use of a method as in claim 1 in a broadband wireless access service.

1643

1644 169. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1645 broadband wireless access service.

1646

1647 170. (original) The use of a method as in claim 1 in a municipal area network.

1648

1649 171. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a  
1650 municipal area network.

1651

1652 172. (original) The use of a method as in claim 1 in a wide area network.

1653

1654 173. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a wide  
1655 area network.

1656

1657 174. (original) The use of a method as in claim 1 in wireless backhaul.

1658

1659 175. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless  
1660 backhaul.

1661

1662 176. (original) The use of a method as in claim 1 in wireless backhaul.

1663

1664 177. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless  
1665 backhaul.

1666

1667 178. (original) The use of a method as in claim 1 in wireless SONET.

1668

1670 179. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless  
1671 SONET.

1672

1673

1674 180-181. (CANCELLED)

1675

1676

1677 182. (original) The use of a method as in claim 1 in wireless Telematics.

1678

1679

1680 183. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless  
1681 Telematics.

1682

1683

1684 184. (NEW) An apparatus as in claim 101, wherein the means for digital signal  
1685 processing in said first subset of MIMO-capable nodes further comprises:  
1686       an ADC bank for downconversion of received RF signals into digital signals;  
1687  
1688       a MT DEMOD element for multitone demodulation, separating the received  
1689       signal into distinct tones and splitting them into 1 through  $K_{\text{feed}}$  FDMA  
1690       channels, said separated tones in aggregate forming the entire baseband for the  
1691       transmission, said MT DEMOD element further comprising  
1692           a Comb element with a multiple of 2 filter capable of operating on a 128-  
1693           bit sample; and,  
1694           an FFT element with a 1,024 real-IF function;  
1695  
1696       a Mapping element for mapping the demodulated multitone signals into a 426  
1697       active receive bins, wherein  
1698           each bin covers a bandwidth of 5.75MHz;  
1699           each bin has an inner passband of 4.26MHz for a content envelope;  
1700           each bin has an external buffer, up and down, of 745kHz;

1701                   each bin has 13 channels, CH0 through CH12, each channel having 320  
1702                   kHz and 32 tones, T0 through T31, each tone being 10kHz, with the inner  
1703                   30 tones being used information bearing and T0 and T31 being reserved;  
1704                   each signal being 100 $\mu$ s, with 12.5 $\mu$ s at each end thereof at the front and  
1705                   rear end thereof forming respectively a cyclic prefix and cyclic suffix  
1706                   buffer to punctuate successive signals;

1707                   and,

1708                   a symbol-decoding element for interpretation of the symbols embedded in the  
1709                   signal.

1710

1711

1712   185. (NEW)   A wireless electromagnetic communications network, comprising  
1713                   a set of nodes, said set further comprising,  
1714                   at least a first subset of MIMO-capable nodes, each MIMO-capable node  
1715                   comprising:  
1716                   a spatially diverse antennae array of  $M$  antennae, where  $M \geq$  two,  
1717                   said antennae array being polarization diverse, and circularly  
1718                   symmetric, and providing 1-to- $M$  RF feeds;  
1719                   a transceiver for each antenna in said array, said transceiver  
1720                   further comprising:  
1721                   a Butler Mode Forming element, providing spatial  
1722                   signature separation with a FFT-LS algorithm,  
1723                   reciprocally forming a transmission with shared receiver  
1724                   feeds, such that the number of modes out equals the  
1725                   numbers of antennae, establishing such as an ordered set  
1726                   with decreasing energy, further comprising:  
1727                   a dual-polarization element for splitting the  
1728                   modes into positive and negative polarities with  
1729                   opposite and orthogonal polarizations, that can  
1730                   work with circular polarizations; and,  
1731                   a dual-polarized link CODEC;

1732 a transmission/reception switch comprising:  
1733 a vector OFDM receiver element;  
1734 a vector OFDM transmitter element;  
1735 a LNA bank for a receive signal, said LNA Bank  
1736 also instantiating low noise characteristics for a  
1737 transmit signal;  
1738 a PA bank for the transmit signal that receives  
1739 the low noise characteristics for said transmit  
1740 signal from said LNA bank;  
1741 an AGC for said LNA bank and PA bank;  
1742 a controller element for said  
1743 transmission/reception switch enabling baseband  
1744 link distribution of the energy over the multiple  
1745 RF feeds on each channel to steer up to  $K_{\text{feed}}$   
1746 beams and nulls independently on each FDMA  
1747 channel;  
1748 a Frequency Translator;  
1749 a timing synchronization element controlling said  
1750 controller element;  
1751 further comprising a system clock,  
1752 a universal Time signal element;  
1753 GPS;  
1754 a multimode power management element and  
1755 algorithm;  
1756 and,  
1757 a LOs element;  
1758 said vector OFDM receiver element comprising:  
1759 an ADC bank for downconversion of received  
1760 RF signals into digital signals;  
1761 a MT DEMOD element for multitone  
1762 demodulation, separating the received signal into

1763 distinct tones and splitting them into 1 through  
1764  $K_{\text{feed}}$  FDMA channels, said separated tones in  
1765 aggregate forming the entire baseband for the  
1766 transmission, said MT DEMOD element further  
1767 comprising:  
1768 a Comb element with a multiple of 2  
1769 filter capable of operating on a 128-bit  
1770 sample; and,  
1771 an FFT element with a 1,024 real-IF  
1772 function;  
1773 a Mapping element for mapping the demodulated  
1774 multitone signals into a 426 active receive bins,  
1775 wherein  
1776 each bin covers a bandwidth of 5.75  
1777 MHz;  
1778 each bin has an inner passband of 4.26  
1779 MHz for a content envelope;  
1780 each bin has an external buffer, up and  
1781 down, of 745 kHz;  
1782 each bin has 13 channels, CH0 through  
1783 CH12, each channel having 320 kHz and  
1784 32 tones, T0 through T31, each tone  
1785 being 10 kHz, with the inner 30 tones  
1786 being used information bearing and T0  
1787 and T31 being reserved;  
1788 and,  
1789 each signal being 100  $\mu\text{s}$ , with 12.5  $\mu\text{s}$  at  
1790 each end thereof at the front and rear end  
1791 thereof forming respectively a cyclic  
1792 prefix and cyclic suffix buffer to  
1793 punctuate successive signals;

1794 a MUX element for timing modification capable  
1795 of element-wise multiplication across the signal,  
1796 which halves the number of bins and tones but  
1797 repeats the signal for high-quality needs;  
1798 a link CODEC, which separates each FDMA  
1799 channel into 1 through  $M$  links, further  
1800 comprising:  
1801     a SOVA bit recovery element;  
1802     an error coding element;  
1803     an error detection element;  
1804     an ITI remove element;  
1805     a tone equalization element;  
1806     and,  
1807     a package fragment retransmission  
1808     element;  
1809     a multilink diversity combining element, using a  
1810     multilink Rx weight adaptation algorithm for Rx  
1811     signal weights  $\mathbf{W}(k)$  to adapt transmission  
1812     gains  $\mathbf{G}(k)$  for each channel  $k$ ;  
1813     an equalization algorithm, taking the signal from  
1814     said multilink diversity combining element and  
1815     controlling a delay removal element;  
1816     said delay removal element separating  
1817     signal content from imposed pseudodelay  
1818     and experienced environmental signal  
1819     delay, and passing the content-bearing  
1820     signal to a symbol-decoding element;  
1821     said symbol-decoding element for  
1822     interpretation of the symbols embedded  
1823     in the signal, further comprising:

1824 an element for delay gating;  
1825 a QAM element; and  
1826 a PSK element;  
1827 said vector OFDM transmitter element comprising:  
1828 a DAC bank for conversion of digital signals into  
1829 RF signals for transmission;  
1830 a MT MOD element for multitone modulation,  
1831 combining and joining the signal to be  
1832 transmitted from 1 through  $K_{\text{feed}}$  FDMA  
1833 channels, said separated tones in aggregate  
1834 forming the entire baseband for the transmission;  
1835 said MT MOD element further comprising  
1836 a Comb element with a multiple of 2  
1837 filter capable of operating on a 128-bit  
1838 sample; and,  
1839 an IFFT element with a 1,024 real-IF  
1840 function;  
1841 a Mapping element for mapping the modulated  
1842 multitone signals from 426 active transmit bins,  
1843 wherein  
1844 each bin covers a bandwidth of 5.75  
1845 MHz;  
1846 each bin has an inner passband of 4.26  
1847 MHz for a content envelope;  
1848 each bin has an external buffer, up and  
1849 down, of 745 kHz;  
1850 each bin has 13 channels, CH0 through  
1851 CH12, each channel having 320 kHz and  
1852 32 tones, T0 through T31, each tone  
1853 being 10 kHz, with the inner 30 tones

1854 being used information bearing and T0  
1855 and T31 being reserved;  
1856 each signal being 100  $\mu$ s, with 12.5  $\mu$ s at  
1857 each end thereof at the front and rear end  
1858 thereof forming respectively a cyclic  
1859 prefix and cyclic suffix buffer to  
1860 punctuate successive signals;  
1861 a MUX element for timing modification capable  
1862 of element-wise multiplication across the signal,  
1863 which halves the number of bins and tones but  
1864 repeats the signal for high-quality needs;  
1865 a symbol-coding element for embedding the  
1866 symbols to be interpreted by the receiver in the  
1867 signal, further comprising:  
1868     an element for delay gating;  
1869     a QAM element; and  
1870     a PSK element;  
1871 a link CODEC, which aggregates each FDMA  
1872 channel from 1 through  $M$  links, further  
1873 comprising:  
1874     a SOVA bit recovery element;  
1875     an error coding element;  
1876     an error detection element;  
1877     an ITI remove element;  
1878     a tone equalization element;  
1879     and,  
1880     a package fragment retransmission  
1881     element;  
1882 a multilink diversity distribution element, using a  
1883 multilink Tx weight adaptation algorithm for Tx  
1884 signal weights to adapt transmission gains

1885  $\mathbf{G}(k)$  for each channel  $k$ , such that  $\mathbf{g}(q;k)$   
1886  $\propto \mathbf{w}^*(q;k)$ ;

1887 a TCM codec;

1888 a pilot symbol CODEC element that integrates with said FFT-LS

1889 algorithm a link separation, a pilot and data signal elements

1890 sorting, a link detection, multilink combination, and equalizer

1891 weight calculation operations;

1892 means for diversity transmission and reception,

1893 and,

1894 means for input and output from and to a non-radio interface;

1895

1896 said set of nodes being linked according to design rules that favor the following

1897 criteria:

1898 subdividing said set of nodes further comprising into two or more proper

1899 subsets of nodes, with a first proper subset being the a transmit uplink /

1900 receive downlink subset, and a second proper subset being the a transmit

1901 downlink / receive uplink subset;

1902

1903 allowing each node in said set of nodes to simultaneously belong

1904 belonging to no more only as many transmitting uplink or receiving uplink

1905 subsets than as it has diversity capability means;

1906

1907 allowing each node in a the transmit uplink / receive downlink subset has

1908 no more to simultaneously link to only as many nodes with which it will

1909 hold time and frequency coincident communications in its field of view,

1910 than as it has diversity capability means;

1911

1912 allowing each node in a the transmit downlink / receive uplink subset has

1913 no more to simultaneously link to only as many nodes with which it will

1914 hold time and frequency coincident communications in its field of view,  
1915 ~~than as~~ it has diversity capability means;  
1916 allowing each member of a the transmit uplink / receive downlink subset  
1917 ~~cannot hold to engage in simultaneous~~, time and frequency coincident  
1918 communications with any other member of that transmit uplink / receive  
1919 downlink subset only if both that other member also belongs to a different  
1920 proper subset and the communication is between different proper subsets;  
1921 and,  
1922 allowing each member of a the transmit downlink / receive uplink subset  
1923 ~~cannot hold to engage in simultaneous~~, time and frequency coincident  
1924 communications with any other member of that transmit downlink /  
1925 receive uplink subset only if both that other member also belongs to a  
1926 different proper subset and the communication is between different proper  
1927 subsets;  
1928  
1929 means for transmitting, in said wireless electromagnetic communications network,  
1930 independent information from each node belonging to a first proper subset, to one  
1931 or more receiving nodes belonging to a second proper subset that are viewable  
1932 from the transmitting node;  
1933  
1934 means for processing independently, in said wireless electromagnetic  
1935 communications network, at each receiving node belonging to said second proper  
1936 subset, information transmitted from one or more nodes belonging to said first  
1937 proper subset;  
1938  
1939 and,  
1940  
1941 means for deploying said set of nodes such that substantially reciprocal symmetry  
1942 exists for the uplink and downlink channels by,  
1943 if the received interference is spatially white in both link directions, setting

1944  $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$  and  $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$  at both ends of the link,  
 1945 where  $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$  are the linear transmit and receive weights  
 1946 used in the downlink;  
 1947  
 1948 but if the received interference is not spatially white in both link  
 1949 directions, constraining  $\{\mathbf{g}_1(q)\}$  and  $\{\mathbf{g}_2(q)\}$  to satisfy:  
 1950

$$1951 \sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

1952  
 1953  $\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2;$   
 1954  
 1955 using any standard communications protocol, including TDD, FDD, simplex,  
 1956  
 1957 and,  
 1958  
 1959 means for optimizing the network by dynamically adapting the diversity  
 1960 capability means between nodes of said transmitting and receiving subsets.  
 1961  
 1962  
 1963 186. (NEW) An apparatus as in claim 185, wherein said a transmission/reception  
 1964 switch further comprises an element for tone and slot interleaving.  
 1965  
 1966 187. (NEW) An apparatus as in claim 185, wherein said TMC codec and SOVA bit  
 1967 recovery element are replaced with a Turbo codec.  
 1968